B-1410

Suggestions for Controlling Insects in Farm-Stored Grain

The Texas A&M
University System

Texas
Agricultural
Extension
Service

Zerle L. Carpenter, Director
College Station

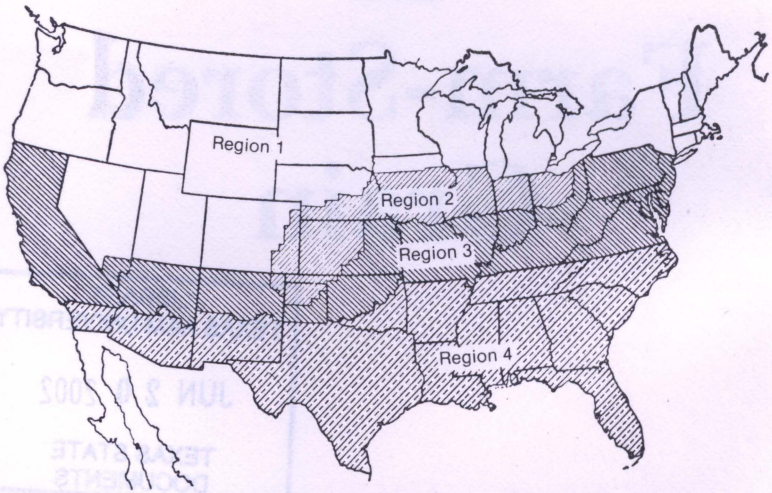


Figure 1. The map shows, by regions, the degree to which farm-stored grain in the United States is subject to insect attack: Region 1, little if any damage occurs to grain on the farm during the first season's storage. Region 2, insects may be troublesome during the first season. Region 3, insects are troublesome every year. Region 4, insects are a serious problem throughout the storage period. (Courtesy USDA)

Suggestions for Controlling Insects in Farm-Stored Grain

*Philip J. Hamman**

Texas producers annually store millions of bushels of grain, of which a great amount is subject to devastation by stored-grain insects. The potential for losses exists, even under the best storage conditions, since the relatively mild weather conditions promote insect growth and development year around. However, reducing or eliminating a favorable environment prior to and at storage time helps prevent later infestations. Insect population increases are greatly favored by improperly cleaned and maintained storage structures, or too high temperatures and high grain moisture at binning.

Importance of Keeping Insects Out of Stored Grains

Grain prices are based on clean, dry, wholesome grain. Anything that lowers quality also lowers its price. Insect damage reduces grain quality and may make the grain unsalable. Insects or their parts, droppings, webbing, heat and moisture that they cause in grain, broken grains, and odors all contribute to the loss.

Insects in farm-stored grain also affect the grain's eligibility for the U.S. Government Grain Reserve Program. Storage structure condition and the stored commodity are factors the Agricultural Stabilization and Conservation Service (ASCS) commodity inspector considers when determining eligibility for a farm-storage loan. If a loan is approved, the producer is responsible for any loss in quantity or quality of the commodity caused by insect infestation or rodent damage.

Furthermore, U.S. producers are increasingly dependent on foreign sales and grain quality is very important to overseas buyers. This is yet another reason for protecting stored grain against insects and other damage.

**Extension urban entomologist, The Texas A&M University System.*

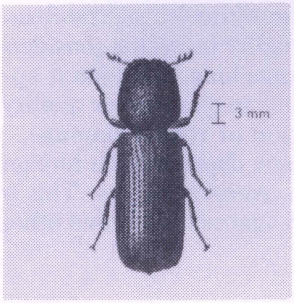
Kinds of Stored Grain Insects

Insects that attack stored grain are classified as *primary* (those that attack whole kernels and complete their development inside the kernel) and *secondary* (those that feed primarily on cracked or broken kernels).

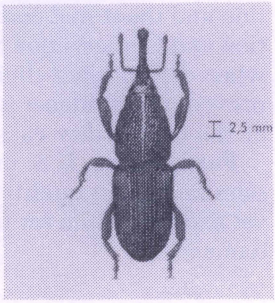
Primary Pests

Three primary pest species — rice or corn weevil, *Sitophilus oryzae* (L.), lesser grain borer, *Rhizopertha dominica* (F.), and Angoumois grain moth, *Sitotroga cerealella* (Oliv.) — are the most destructive stored-grain insects in Texas. The granary weevil, *Sitophilus granarius* (L.), also a primary pest, rarely occurs in damaging numbers in Texas. In the immature stages, these insects feed within the kernel unseen and usually unsuspected. These immature stages cannot be removed by ordinary cleaning machinery and in most cases must be controlled by fumigation.

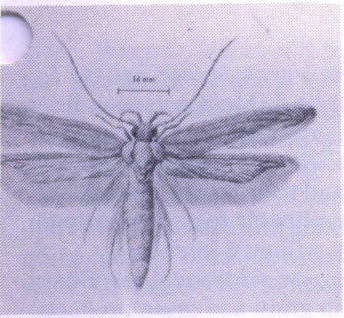
The *rice or corn weevil* is about 1/8-inch long and can fly long distances. Infestations may occur in the field when the grain begins to ripen, especially in grain sorghum. The rice or corn weevil can be distinguished from the granary weevil by the four light spots on its wing covers, and by the fact that it can fly. The *granary weevil* is slightly larger than the rice weevil, but it cannot fly; consequently, infestations are more limited. Both species are destructive in the larval and adult stages. The *lesser grain borer* is a small, dark brown or black beetle with a roughened surface, about 1/8-inch long and 1/32-inch wide. Its head turns down under the thorax. The adult *Angoumois grain moth* is small and buff-colored, with a wing spread of 1/2 to 2/3-inch. The hind wings have a heavy fringe of hairs longer than the wing width. The adults do not feed on grain. The females deposit eggs on the kernel, and the young larvae bore into the seed and destroy it. This insect also may infest grain in the field.



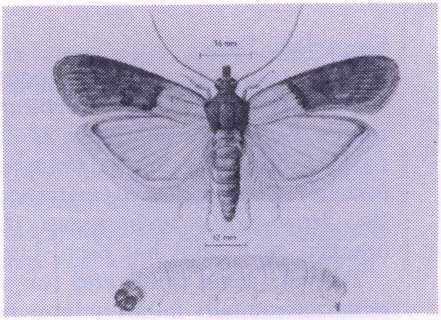
Lesser grain borer



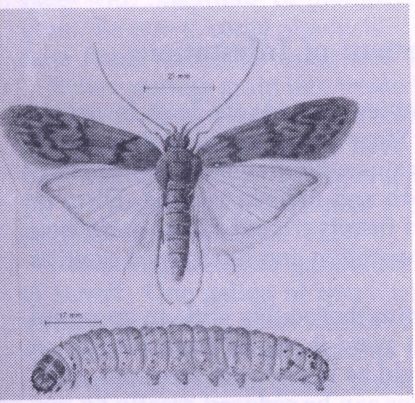
Rice weevil



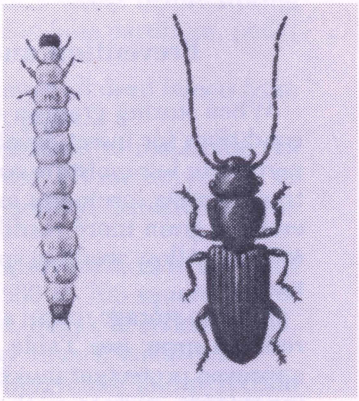
Angoumois grain moth



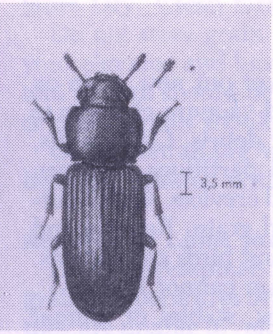
Indian meal moth



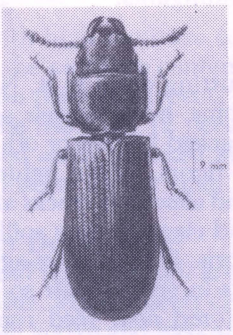
Mediterranean flour moth



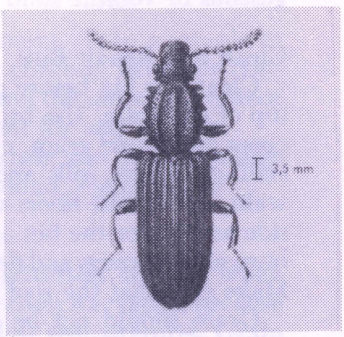
Flat grain beetle ⊥ *1.5 mm*



Confused flour beetle



Cadelle



Saw-toothed grain beetle

Secondary Pests

Some common species of secondary stored-grain insects are the Indian meal moth, *Plodia interpunctella* (Hubn.), Mediterranean flour moth, *Ephestia kuehniella* (Zell.), flat grain beetle, *Cryptolestes pusillus* (Schon.), confused flour beetle, *Tribolium confusum* (J.du.V.), cadelle, *Tenebroides mauritaniaus* (L.) and saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.). These insects feed primarily on cracked grain that has been damaged by primary insects.

Psocids, grain mites and fungus beetles are additional secondary pests occasionally found in large numbers in grain and grain products. These insects and related pests feed on fungus and indicate that the grain is in poor condition.

Prevention and Treatment of Infestations

When storing grain in farm facilities, provide the least favorable conditions for insect development. Store clean, sound grain with 12 percent or less moisture content. Grain containing more moisture attracts insects, promotes mold growth and induces heating. Dirty or cracked grain more readily attracts insects. *Avoid filling grain bins too full.* Allow working space for inspecting and fumigating grain as needed.

Prior to storage, clean and treat bins thoroughly with an approved residual spray (see Table 1). When grain is put in final storage, an approved protectant insecticide should be mixed with the grain. During storage, surface moth infestations can be reduced greatly by surface spray treatments using certain materials. Control of other pests feeding below the surface requires thorough fumigation with liquid, gaseous or volatile solid fumigants.

Clean and Repair Bins

Clean the bin before putting grain in it. Never put new grain on top of old grain. Use brooms, hoes, shovels and vacuum cleaners to clean out all old grain, cracked kernels or other debris. Clean walls, ceilings, ledges, sills and floors. Clean behind partitions, between walls, under false floors and clean out cracks and crevices. Check outside and under the bin and clean up any spilled grain. Remove and burn all sweepings and debris. Plug all holes against birds and rodents. Make sure that the roof is in good repair so rain cannot leak in.

Grain should not be stored near feed rooms, stables or animal feeders, since these areas may harbor insects which can infest the stored

grain. Wagons, trucks and combines in which waste grain accumulates can also house infesting insects and should be cleaned prior to hauling grain to storage facilities.

As another pre-binning precaution, the first few bushels of corn or other grains going through the combine should be fed to livestock. This assures cleanout of any leftover grain in the machine.

Eliminate weeds and grass under and around storage facilities, since grain spills in these areas are concealed and will provide an environment for insect development.

Residual Sprays

After the bin is thoroughly cleaned, spray all inside and outside surfaces with malathion or methoxychlor about 2 weeks before storing grain. Be sure to spray removable doors, behind false partitions, under false floors and other areas (see Table 1).

Before putting grain into treated bins, remove all dead insects from the bin floor to avoid contaminating clean grain.

Indian meal moth larvae have become resistant to malathion. In bins where this insect has been a problem, use: (1) methoxychlor, or (2) 0.1 percent pyrethrin plus 1 percent piperonyl butoxide for the residual treatment (see Table 1).

Use a compressed air garden sprayer and spray surfaces to the point of runoff. One gallon of spray will cover 500 to 700 square feet of surface, depending upon whether it is a wood, metal, or concrete wall. A porous wood surface requires more spray than a metal wall.

Caution: Premium grade malathion, methoxychlor and pyrethrin plus piperonyl butoxide are registered for use in storage bins for barley, corn, oats, rye, sorghum and wheat, *but not soybeans.*

Store Dry, Clean Grain

Do not store grain with high moisture content. Take a sample to your elevator and have the moisture content checked. Moisture content of corn should be less than 14 percent, and the moisture content of other grains should be less than 12 percent for safe storage.

Grain containing weed seeds, cracked kernels and other dockage becomes infested with insects sooner than sound, clean grain.

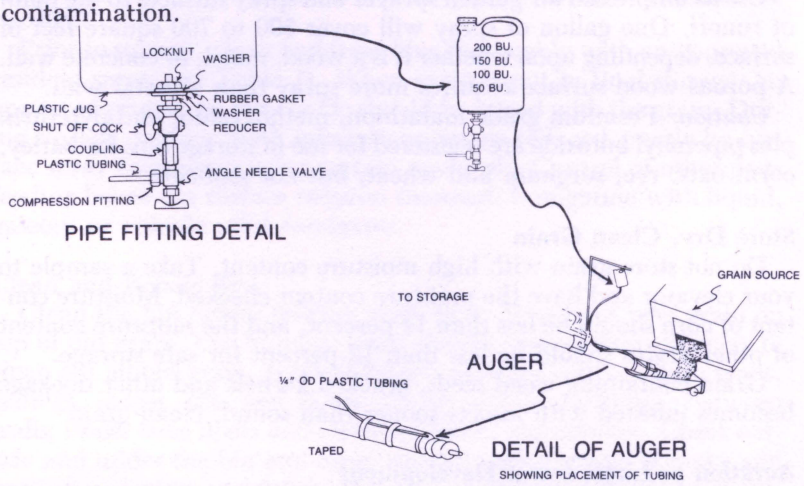
Aeration to Limit Insect Development

Insect development and reproduction are adversely affected when grain temperatures decline. Many insects die from starvation because they are unable to remain active and feed at low temperatures. Grain can be cooled by equipping storage structures with an air distribu-

tion system that forces air through the grain when atmospheric or outside air temperature is lower than the grain temperature. This removes heat from the grain and exhausts it from the bin. Because outside air is used in cooling grain, operating aeration equipment depends on the prevailing weather conditions. Air temperatures of 20 degrees F. or more below the grain temperature are usually selected to cool the grain.

Generally, aeration equipment is not operated during prolonged periods of rain or fog. When cool atmospheric air is moved through grain, the incoming air and the grain through which it flows equalize in temperature. This creates a cooling front that moves in the direction of the airflow. Moisture condensation often is associated with the cooling front. Therefore, once a cooling front or zone is started through the grain, the aeration system should be operated long enough to move the zone completely through the grain mass; otherwise, a moist layer of grain may be left in the grain mass that will provide conditions for mold and insect development. Airflow rates are usually 1/10 cubic foot per minute per bushel or less for dry storable grain. The effects of humidity are less important in West Texas than in the coastal areas.

Aeration cooling alone may not completely control insects, but when used with conventional chemical controls, it can provide considerable protection against quality losses from insect damage and contamination.



A simple method of metering a grain protectant onto the grain as it is augered into the bin. Insert (upper left) shows details of the equipment (Courtesy USDA).

Grain Protectants

Dry, insect-free small grain or shelled corn can be protected from most insect damage by using malathion (see Table 1).

Apply insecticide to the grain stream as it comes out of the combine if grain is dry, or as it is being elevated into the bin. Forcing heated air through grain treated with malathion reduces the effectiveness of the malathion. When using heat, dry the grain first, then apply the malathion after the grain has cooled.

After binning is completed, *level the grain*. If the grain surface is not level and grain has to be fumigated later, the low spots will collect most of the fumigant, while the high spots will not be fumigated. Also, there will be an uneven effect during aeration. Leave at least 6 inches of space between the top of the leveled grain surface and the top of the bin wall so that the fumigant will not "spill over" the sides.

"Topdress" Treatment

Topdress the bin by treating all the surface grain with malathion or pyrethrin grain protectant. Use pyrethrin where Indian meal moths have been a problem (Table 1).

The "topdressing" acts as a barrier, preventing insects from entering the grain mass and from feeding on the surface grain. Each time the surface grain is disturbed, such as when probing for moisture or insect samples, the barrier is broken. Retreat disturbed areas with grain protectant.

Indian Meal Moths

The adult Indian meal moth is about 1/3- to 1/2-inch long. Wing tips are dark red or brown, with the basal one-third light gray. Full grown larvae are about 1/2-inch long, dirty white, sometimes with a pinkish or greenish tinge; the head is dark brown.

Larvae feed only in the upper portion of the grain mass unlike other stored grain insects that feed throughout the bin. The top 1 to 2 inches of grain is often webbed together by Indian meal moth larvae. Where the infestation is severe, a crust of webbing and trash will be very obvious. This crust hinders fumigant penetration and protects the larvae from contacting the grain protectant "topdressing." Remove the crust and damaged grain before treatment or before the grain bin is emptied.

Larvae prefer to feed on cracked or broken seeds, or weed seeds, but will feed on the germ of whole kernels.

If Indian meal moths have been a problem, a "topdress" of pyrethrin plus piperonyl butoxide should be used, since these insects are resistant to malathion. However, malathion is still recommended as a protectant for the bulk of the grain since it is the most economical material, has a longer residual period, and controls the other insects found in the grain mass. The use of another insecticide for the "topdressing" is desirable only where Indian meal moths are a problem. Use pyrethrin plus piperonyl butoxide in these situations as the "topdressing" insecticide.

Table 1. Stored grain bin insecticides and protectants.

Use	Insecticide and Dosage		
	malathion Use premium grade malathion labeled specifically for use in grain bins and on stored grain.	methoxychlor	pyrethrin plus piperonyl butoxide
Residual	1/3 pt 57% malathion per 1 gal of water	3/4 pt 25% methoxychlor E.C. per 1 gal of water	0.1% pyrethrin plus 1% piperonyl butoxide
Grain protectant (per 1,000 bushels of grain)	1 pt 57% malathion E.C. per 2-5 gal of water, or 50 lbs. of 1% malathion dust, or 10 lbs. of 6% malathion dust		
Top-dress (per 1,000 sq ft of grain surface)	1/2 pt 57% malathion E.C. in 1-2 gal of water, or 30 lbs of 1% malathion dust, or 5 lbs. of 6% malathion dust		0.3% pyrethrin plus 3% piperonyl butoxide in 1-2 gal of water

Caution: Premium grade malathion and pyrethrin plus piperonyl butoxide are registered for use on stored barley, corn, oats, rye, sorghum and wheat, *but not on stored soybeans*. Grain treated with malathion or pyrethrin plus piperonyl butoxide as recommended can be fed safely or sold at any time after treating.

Use of *Bacillus thuringiensis*

Some flour moths that infest grain, such as the Indian meal moth and the almond moth, have become increasingly resistant to malathion. A commercial formulation of the biological agent *Bacillus thuringiensis*, a bacterium that controls moth larvae, has been approved for use in stored grains and soybeans. This material (see commercial label for dilution and application rate) is mixed with the surface 4-inch layer of grain either by adding to the last grain as it is augered into the bin or, after the grain is binned, by applying to the surface and mixing with a scoop or rake to a depth of 4 inches. This treatment will not control weevils or other beetles that infest grain. The *B. thuringiensis* formulation is exempt from tolerance restrictions, and the treated grain can be used at any time after treatment for any use.

Resin Strips

Resin strips are thin plastic strips impregnated with dichlorvos. When these strips are hung in a closed area, they give off vapor that kills insects. To be successful, the area to be protected must be without ventilation because air exchange reduces the concentration of the vapor so much that it no longer kills insects.

The strips will control Indian meal moths in tight storage areas if they are hung above the grain with one strip for each 1,000 cubic feet of air space over the grain. The strips must be hung before moths begin to emerge in the spring. Strips will last up to 4 months. If strips are used, check grain once each month for insect buildup. Replace strips if pests are seen.

Check for Insects

Examine grain regularly to detect early infestations of insects. If an infestation is detected early, insects can be controlled before they have caused extensive damage. There are minimum acceptable levels of damage and contamination.

Follow a systematic procedure for making probes. Empty each sample into a grain sampling tray or section of eaves trough long enough to accommodate the grain probe. Sift the samples through a 10 to 12 mesh per inch screen and examine for insects.

During cold weather, insects congregate near the grain mass center where it is warmest, so sample the center thoroughly during the winter. During warm weather, infestations usually begin near the surface, so pay special attention to that area during the summer.

In the winter, when the grain is cooler, sample the grain every 4 to 6 weeks. During warmer months, sample grain every 2 to 4 weeks. Use a grain probe which may be purchased or borrowed from your local grain buyer.

When first entering the bin, insert the probe horizontally 2 inches under the grain surface in the bin center before the grain surface is disturbed. Collect the sample and examine for insects. Take additional surface samples around the sides of the bin. Then probe from the top to the bottom of the grain mass. Extensions may have to be attached to the probe so that it can penetrate to the bin floor.

In round bins, start the deep probes at the center, then probe around the wall. Insert the probe about 1 foot from the outer wall. Make surface and deep probes at the north, west, south and east sides of the bin. Examine each sample for insects. In extremely large bins, samples may have to be taken at more locations, no farther apart than every 20 feet round the wall. Bins more than 40 feet in diameter should be sampled more than once near the bin center.

In flat storage bins, grain should be sampled in the center and around the walls. Take samples no farther than 20 feet apart. Take surface probes first, then probe from the top to the bottom, examining each sample for insects.

Always retreat surface with topdressing of grain protectant after disturbing grain.

If you find considerable damage and/or insects in the probe samples and cannot identify the insects, you should show them to the county Extension agent or elevator manager for positive identification. If one granary weevil, one rice weevil or one lesser grain borer, or as many as five insects of other species such as flour beetles and saw-toothed grain beetles are found per quart sample of grain, fumigation is necessary to prevent further insect damage. Grain temperature should be above 65 degrees F. for the fumigant to be effective.

Fumigation

It is usually less expensive and more effective to have a commercial company fumigate than to attempt to do it yourself, particularly if large quantities of grain (over 10,000 bushels) need to be fumigated. Consider the cost of application on a per bushel basis. The cost should include the necessary safety and application equipment, as well as the cost of the fumigant. The time and labor expense should also be considered.

Flat storage structures and large round bins present special problems in maintaining the fumigant in place long enough to kill effectively.

Recirculating the fumigant is a technique often used by commercial applicators in flat structures to distribute the fumigant more uniformly throughout the grain. This is accomplished by attaching a return duct between the overhead space above the grain surface and the fan on the aeration duct. Depending on the direction of the air movement, the fumigant can be drawn or pushed through the grain and then directed back to the grain by return duct. The fumigant is generally recirculated long enough to produce 2 or more air changes within the stored commodity. Grain may be fumigated effectively at greater depths when bins are equipped with recirculating equipment.

Applicators must have state certification to purchase and apply fumigants, since fumigants are restricted-use pesticides.

Bin Preparation

Seal all cracks. If the bin has many openings that cannot be sealed to prevent fumigant leakage, fumigation will not be effective.

Circular storage structures constructed from corrugated metal strips and quonsets and other rectangular buildings constructed of corrugated and flat metal bolted together are usually the most gastight. Caulking the seams during construction improves bin tightness. Seal fan outlets with polyethylene sheeting to prevent gas leakage.

Wood structures are the most difficult to fumigate because they are porous and allow an excessive amount of fumigant to escape. For this reason, fumigant dosage recommendations for wooden bins are usually twice the amount recommended for metal bins. The wooden structure may have to be covered with a gastight tarpaulin to retain the fumigant for a sufficient length of time.

Before applying the fumigant, spray the outside of the bin with a residual spray of premium grade malathion or methoxychlor (Table 1) to kill those insects forced out of the bin by the fumigant. Otherwise, these insects could quickly reinfest the grain after the fumigant disappears. Also, clean up and dispose of any waste grain outside the bin for the same reason.

Fumigant Selection

All fumigants are poisons and are toxic to humans and other warm-blooded animals, as well as to insects and other pests. Certain fumigants are highly flammable and corrosive. Some will leave undesirable residues if not used correctly. Some will injure seed germination and affect milling quality if improperly used (Table 2).

Table 2. Characteristics of several grain fumigants.

Fumigant	Heavier than air	Grain Penetration	Flammability	Warning odor	Germination effect
Carbon disulfide	Yes	Good	High	Rotten egg	Depresses
Carbon tetrachloride	Yes	Good	None	Pungent odor	Depresses
Ethylene dibromide	Yes	Poor	None	Sweet	Depresses
Ethylene dichloride	Yes	Poor	High	Ether odor	Little
Chloropicrin	Yes	Poor	None	Tear gas	Depresses
Sulfur dioxide	Yes	-	None	Irritating	Destroys
Methyl bromide	Yes	Excellent	None	None	Depresses
Aluminum phosphide	Slightly	Excellent	In Presence of Moisture	Carbide-like	None

Aeration of the grain after fumigation is a necessity.

Fumigants are most effective when the air is calm and grain temperature is 65 degrees F. or above. Remember that changes in average temperatures in grain lag 6 to 8 weeks behind changes in average air temperature.

Fumigants are available in liquid, gas and solid formulations. However, all fumigants must become a gas to be effective.

Liquid Fumigants. Liquid formulations usually contain a mixture of 2 or more compounds. Liquids commonly used in farm fumigants are combinations of carbon tetrachloride with carbon disulfide, ethylene dibromide, or ethylene dichloride. Carbon disulfide should not be used alone because it is extremely explosive and flammable.

Liquid fumigants usually are applied to the grain surface. Because they are heavier than air, they settle to the bottom of the grain mass. Chloropicrin (tear gas) or sulfur dioxide are sometimes added to these mixtures as warning agents.

The fumigants listed in Table 3 may reduce seed germination if moisture is too high or if applied at higher dosages than recommended.

Table 3. Recommended Insecticide Fumigants

Fumigant Mixtures[2]	Type of Bin[3]	Gallons per 1000 bushels[1] Shelled Corn & Oats	Grain Sorghum	Wheat, Rye, Barley
80% carbon tetrachloride + 20% carbon bisulfide[4]	Metal	3.5	5	3
	Wood	7	10	6
75% ethylene dichloride + 25% carbon tetrachloride	Metal	5	8	3.5
	Wood	10	10	7
5% ethylene dibromide[5] + 35% ethylene dichloride + 60% carbon tetrachloride	Metal	3.5	5	3
	Wood	7	10	6

[1]For lots of 500 to 1000 bushels, use the same dosage as recommended for 1000 bushels; with smaller lots, thoroughly wet the surface with fumigant.

[2]Other fumigant formulations are available under various trade names; if applied ac cording to directions, they are just as effective as the ones listed.

[3]Concrete bins use the same dosage recommendations as listed for metal bins.

[4]Carbon bisulfide is highly explosive when used without a fire suppressant such as carbon tetrachloride.

[5]Grain treated with fumigants containing ethylene dibromide should be thoroughly aerated before feeding to laying hens.

Gaseous Fumigants. Methyl bromide may be used to fumigate grain in piles or in bags if it is not to be used for planting, since this process may lower germination. Methyl bromide is usually released from a pressurized container into the storage area and commodity.

Control with methyl bromide is improved by using an air recirculation system. Gaseous fumigants are extremely hazardous and require special equipment and careful handling. Only experienced persons equipped to use these materials should apply this fumigant.

Solid Fumigants. Solid pellets or tablets containing aluminum phosphide (Phostoxin®) can be used to fumigate farm-stored grain. Tablets or pellets properly placed in the grain mass are activated by moisture in the air to release highly toxic aluminum phosphide gas which contains the active ingredient phosphine. The tablets may be hand fed or machine metered into the grain stream as it is being stored. The pellets may be used in a similar manner or probed down into the

grain after storage. Standard application practices over several years indicate that placement of 2/3 the calculated dosage on top of the grain mass and 1/3 distributed underneath yields good results without having to probe. Cover the grain surface with polyethylene sheeting to contain the gas.

This material is extremely dangerous if improperly used, so only experienced applicators who are thoroughly familiar with the proper use of the material should apply it. Do not pour or spill water on aluminum phosphide pellets.

Volume Calculation

To determine the amount of fumigant required, you must know how many bushels of grain are in the bin. There are several ways of determining grain mass volume. The method does not matter as long as it is accurate. The following formulas are simple to use.

Bushels of grain in a square or rectangular bin:
bushels = 0.8 x length (ft.) x width (ft.) x average depth of grain (ft.).

Bushels of grain in a round bin:
bushels = 0.6283 x diameter (ft.) x average depth (ft.).

Fumigant Dosage

Fumigants are sold under various trade names. Ingredients are listed on the container label. Table 3 shows ingredients and recommended dosages of some readily available liquid fumigants. The list should help in determining how much fumigant will be required. Other effective fumigants also may be available. Always follow the label instructions and recommendations.

The approximate dosage rates for Phostoxin® are given in Table 4. Since it is stored as a solid and releases its vapor after exposure to air, it is applied in a different manner than the liquid fumigants. Only personnel who have been instructed in its use should apply Phostoxin® .

How to Use Fumigants

Always use the recommended dosage of an approved fumigant for the type grain and bin you are treating.

Temperature is a highly significant factor in grain fumigation. As temperature rises, insect respiration and transpiration increases; thus, the recommended fumigant concentration will give better control. As temperature lowers, insect respiration and transpiration decreases; thus, the recommended fumigant concentration will give poorer control.

Table 4. Phostoxin® Recommendation for Controlling Insects in Stored Grains

Stored Product	Dosage	Remarks
Corn Popcorn Wheat Oats Grain sorghum Rye Soybeans	180 tablets or 300 pellets per 1000 bushels	Space tablets or pellets uniformly into stream as the grain is loaded into storage bin. Inject tablets or pellets into bin with a probe or distribute calculated dosage 2/3 on top of grain and 1/3 underneath. Cover grain surface with polyethylene sheeting. Do not expose Postoxin® to water. Wear protective gloves when handling Phostoxin® . In wooden bins, cover grain surface with polyethylene tarpaulin, then use recommended dosage.

Apply fumigants prior to 10:00 a.m. since higher temperatures later in the day cause fumigants to volatize rapidly, lessening insect control and making applications more hazardous.

Another important climatic factor is the wind. High winds outside the grain bin allow small gusts to enter through undetected cracks and crevices and to dilute the fumigant inside. High wind conditions also may siphon the fumigant out of the grain bin through these cracks and crevices.

Fumigants, therefore, are most effective when the grain temperature is 70 degrees to 85 degrees F. and the air is calm.

How to Fumigate

Try to make the grain bin air tight before fumigation. The grain surface should be level to insure even penetration. Apply liquid fumigants to the entire grain surface as a coarse spray. A 3 to 5 gallon capacity hand-type compressed air sprayer may be used to obtain a coarse spray by removing the spray nozzle and flattening the spray rod tip with pliers, or by removing the disc from the spray nozzle.

Use some form of power equipment when fumigating a large volume of grain. Compressed air tanks or brass gear pumps may be used. These pumps may be operated by a small motor or from the power take-off of a tractor. Select or construct a discharge nozzle that disperses the liquid in an even pattern as a coarse spray. Close the bin immediately after applying the fumigant; do not open it for at least 24 hours and preferably 4 or 5 days. Air the bin at least overnight before entering. Fumigated grain may be fed to livestock as soon as no fumigant odor is present.

Fumigants, when applied properly, can penetrate grain and in most cases kill all stages of insects to a depth of 10 to 60 feet. Grain may

be fumigated effectively at greater depths when bins are equipped with proper aeration facilities. Even when fumigation is carried out in structures that are airtight, the movement of outside air influences fumigation efficiency. Consequently, best results are obtained if fumigants are applied when the air is calm.

Place signs at all entrances warning that the bin is being fumigated, listing the fumigant used and the name, address and telephone number of a responsible person to contact in case of emergency.

Preliminary Precautions for Fumigation Operations

1. Allow only experienced or trained persons to perform fumigation operations.
2. Train persons involved in fumigation in artificial respiration.
3. When top seals are removed and the canister is attached to the respirator, the date should be recorded. Write the date on the canister label.
4. When the air inlet seal on the canister is removed, the date should again be recorded.
5. Replace canisters after each fumigation operation.
6. When canisters are discarded, first crush them underfoot so they will not be inadvertently reused. Send canisters immediately to a satisfactory refuse dump.
7. Do not use canisters with signs of external damage. Canisters may be rendered useless if contents have come into contact with water.
8. USE THE PROPER CANISTER FOR THE FUMIGANT USED (see Table 5).
9. *All* persons involved in the fumigation process should wear an approved, fitted respirator for the fumigant in use.
10. Persons with punctured eardrums should wear ear plugs in addition to their respirator.
11. Respirators should be maintained and serviced; canisters should be replaced at regular intervals.
12. A first aid kit containing information and items necessary for treatment of accidental poisoning should be at the site.
13. Check your local poison control center or physician before fumigation to determine if they have antidotes and current information for treatment of fumigant poisoning.

Additional Safety Rules for Fumigation

1. A person should never work alone during fumigation.
2. Never allow children or bystanders in the fumigation area.

3. READ THE LABEL on the fumigant material to be used. Follow directions on the label. Use only for approved purposes.
4. Fumigate on a mild, still day. Temperature should be 60 degrees F. or above.
5. Seal structures to prevent "leaks."
6. Always wear an approved respirator.
7. If fumigant is spilled on clothing or skin, WASH IMMEDIATELY with soap and water.
8. Wear clothing which covers as much of the body as possible.

Table 5. Recommended canisters for respirators used for fumigation purposes.

Fumigant	Canister Type and Color	Canister Contents
Acrylonitrile Carbon Bisulfide Carbon Tetrachloride Ethylene Dibromide Ethylene Dichloride Methyl Bromide Napthalene Mixtures not over 2% of above	Organic vapors-black	Activated Charcoal
Chloropicrin	Organic vapors-black	Activated Charcoal and Alkaline granules (e.g. soda lime)
Ethylene Oxide	Acid gases-white	
Aluminum and magnesium phosphide-not to exceed 0.5% conc.	Specific for phosphine-orange	
Sulphur Dioxide	Acid gases-white	Soda Lime, caustic pumice sodium hydroxide Activated charcoal

The information given herein is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Cooperative Extension Service is implied.

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socioeconomic level, race, color, sex, religion, handicap or national origin.

Cooperative Extension Work in Agriculture and Home Economics, The Texas A&M University System and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.
20M—6-82 AGR12